Cost-Effectiveness of Distributed Energy Resources

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Objectives

- Understand why life-cycle cost analysis is important
- Describe the criteria that determines if a project is "cost-effective"
- Evaluate a project's Life-Cycle Cost (LCC)

Interactive Exercise

System A

- 80% overall efficiency
- Twice the cost of System B
- 15-year lifetime
- No performance track record

System B

- 40% overall efficiency
- Half the cost of System A
- 10-year lifetime
- Excellent performance track record

Which is the better system?

Why Life-Cycle Costing?

- Required for Federal energy projects
  - Provisions set forth in Code of Federal Regulations, Title 10, Part 436, Subpart a
  - Executive Order 13123 stipulates implementation of "life-cycle cost effective" projects
- Economics can improve decisions
  - Capture costs and benefits ***over the project lifetime***
  - Evaluate ***cost/performance*** tradeoffs
  - ***Prioritize*** multiple energy efficiency projects

$$SPB = \frac{Initial\ Cost\ [\$]}{Annual\ Savings\ [\$ / yr]}$$

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Life-Cycle Cost Effectiveness: The Definition

- **Life-Cycle Cost Analysis (LCCA)** determines the costs and benefits of a project over a pre-determined study period
- Life-cycle costs are the sum of the ***present values*** of:
  - Investment Costs
  - Non-fuel operations and maintenance costs
  - Replacement costs
  - Energy costs

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The Ugly Truth

$$LCC = I + Repl - Res + E + W + OM\&R$$

Where	***LCC***	= Total LCC in **present-value dollars**
	I	= Present-value investment costs
	Repl	= Present-value capital replacement costs
	Res	= Present-value residual value (resale, scrap,or salvage value) less disposal costs
	E	= Present-value energy costs
	W	= Present-value water costs
	OM&R	= Present-value non-fuel operating, maintenance, and repair costs

8 Steps for Performing LCCA

1. **Identify alternatives**
2. **Specify data requirements and establish assumptions**
3. **Estimate costs in dollars**
4. **Adjust costs for time value of money**
5. **Compute total LCC for each alternative**
6. **Select alternative with lowest LCC**
7. **Compute supplementary measures (as needed)**
8. **Consider uncertainty in input values (OPTIONAL)**

$$LCC = I + Repl - Res + E + W + OM\&R$$

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Applying the 8 Steps to an Example Problem

60kW Microturbine Cogen Installation (6,000 hrs/yr)

- System Cost

Microturbine Components	= $56,000
Installation (Mech, Elect, Engineering)	= $44,000
Heat Exchanger	= $7,500
GRAND TOTAL	**= $107,500**

- Energy Produced

Electricity	= 288,000 kWh/yr
Heat	= 2,100 MMBtu/yr
O&M Costs	= $0.10/kWh

- Current Energy Costs at the Site

Electricity	= $0.07/kWh
Natural Gas	= $5.00/MMBtu

Step 1: Identify Alternatives

- Establish a base-case scenario
  - Generally the business-as-usual case or the existing conditions
- Alternatives can be
  - Different energy conservation measures (ECMs) for the same facility
  - Different systems
  - Different levels of efficiency within the same system
  - Etc.

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Step 1. Identify Alternatives
(continued)

- For this example,
- Base Case = Business as usual scenario, with all energy supplied from the serving utility
- Alternative = 60kW microturbine installation for cogeneration of electricity and heat (for domestic hot water heating)

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Step 2. Specify Data Requirements and Assumptions

- Data requirements depend on alternatives
- They may include:
  - Investment costs: design, materials, labor, etc.
  - Operations, maintenance and repair (OM&R) costs
  - Estimated annual energy savings
  - Current costs of electricity, natural gas, fuel oil, etc.
  - Replacement costs and/or salvage value

Step 2. Specify Data Requirements and Assumptions
(continued)

- Assumptions may include:
  - Some of the costs noted previously: OM&R, replacement cost, salvage value, etc.
  - Lifetime of components for each alternative: pumps, boilers, generators, etc.
  - Study period for all alternatives → ***all alternatives must be evaluated against the same study period for accurate comparisons of LCC***

How do you determine life-cycle?

- Life-cycle (study period) is:
  - Life of the measure
  - Least common multiple of several option lives
  - Longest option life
  - Period of lease
- Study period is not to exceed 25 years
- For our example, the MT has a rated life of 40,000 hours. At 6,000 hours per year, that's about 7 years of operational lifetime.
  → *Study period = 7 years*

Step 3: Estimate Costs in Dollars

Investment Costs

- ***Software Tools***: HOMER, FRESA / RETScreen, DoD Fuel Cell Spreadsheet, CHP Estimator, DGen-Pro, etc.
- Use ***rules of thumb*** (information from this course, DER How-To Guide)
- Consider the ***GSA Supply Schedule***
- Contact ***manufacturers, FEMP, National Labs***, other resources
- Investigate ***web sites***!

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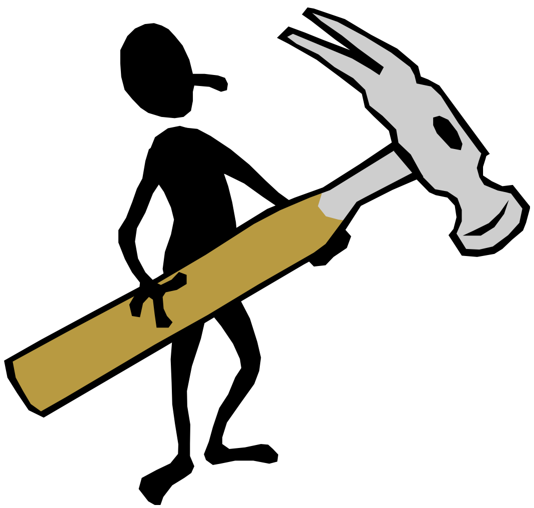
Step 3: Estimate Costs in Dollars (continued)

Operations, Maintenance and Repair (OM&R) Costs

- ***Salvage Value:*** assume straight-line depreciation unless more accurate or historical data is known
- ***Replacement Costs:*** assume current costs at the year of replacement, then discount those costs to present values.



For more conservative analysis, assume no salvage value

Step 3: Estimate Costs in Dollars (continued)

Energy Costs

- Based on quantity of energy at the meter (site vs. source)
- Calculate energy savings of the DER system:
  - Contact vendors, request assistance from FEMP and/or the National Labs
  - Simple software tools and spreadsheet analyses
    - CHP Payback Estimator: **http://www.eren.doe.gov/der/chp/chp-eval1.html**
    - PV Watts **http://rredc.nrel.gov/solar/codes_algs/PVWATTS/**

Step 3: Estimate Costs in Dollars (continued)

- First Year
  - Use local energy costs
- All subsequent years
  - Escalate energy costs according to sector (commercial, residential, or industrial) and census region as in "*Energy Prices and Discount Factors for Life-Cycle Cost Analysis*," NISTIR 85-3273-9, updated every April.

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Accounting for Other Costs and Benefits

- Avoided Costs
  - Distribution system maintenance and repair
  - Utility line extensions (can be $10,000 - $40,000/mile)
  - Travel to remote sites
  - Cost of downtime / poor power quality
  - Air permitting
- Fuel Spill Costs
  - $1.82/gallon of fuel delivered at North Manitou Island ($375/spilled gallon * 0.005 spill probability)

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Accounting for Other Costs and Benefits

- Environmental Emissions Costs
  - National Park Service (DSC Guidance 82-1)
    - $0.75/lb for SO_2
    - $3.40/lb for NO_x
    - $8.00/ton for CO_2
    - Example: NPS values emissions in the State of New Mexico at $0.046/kWh. If you are currently paying $0.08/kWh for electricity in New Mexico, your emissions-adjusted cost is $0.126/kWh.

This significantly changes the economics!

Accounting for Other Costs and Benefits

- Other Qualitative Benefits
  - Agency / organization mission
  - Environmental / P2 goals
  - Improved occupant comfort / employee morale
  - Showcase facility / technology demonstration
  - Meeting Executive Order requirements
  - Supporting surrounding community

Step 4: Adjust Costs for Time Value of Money

- Consider
  - Which costs occur now and which occur in the future?
  - Which occur annually and which do not?

- Discounting a *single future amount* (that occurs in year t)

  $PV = F_t \times SPV_{(t,d)}$ where SPV = ***S****ingle* ***P****resent* ***V****alue factor*

- Discounting a non-energy *recurring annual amount* (over n years)

  $PV = A_0 \times UPV_{(n,d)}$ where UPV = ***U****niform (annual)* ***P****resent* ***V****alue factor*

- Discounting an energy related *recurring annual amount* (over n years)

  $PV = A_0 \times UPV^*_{(n,d)}$

Example

Find the Net Present Value (NPV) of the costs of grid-supplied electricity at this facility, over the next 25 years.

Annual electricity cost at current prices = $10,000

Census Region: 1

Fuel Type: Electricity

Rate Type: Commercial

Study Period: 25 years

Discount Rate: 3.2% (as of April, 2002)

FEMP UPV* Factor: 15.95 (Table Ba-1, page 15)

Solution

Annual electricity cost at current prices = $10,000

Census Region: 1

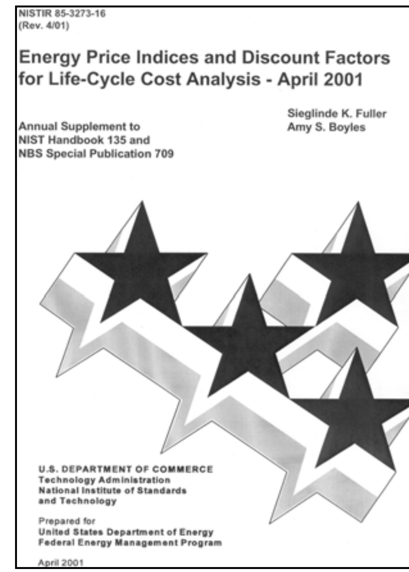
Fuel Type: Electricity

Rate Type: Commercial

Study Period: 25 years

Discount Rate: 3.2% (as of April, 2002)

FEMP UPV* Factor: 15.95 (Table Ba-1, page 15)


NISTIR 85-3273-16
(Rev. 4/01)

Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis - April 2001

Annual Supplement to
NIST Handbook 135 and
NBS Special Publication 709

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NPV = Annual Utility Costs x UPV*

NPV = $10,000 x 15.95 = $159,500

Step 5: Compute Total LCC for Each Alternative

$$LCC = I + Repl - Res + E + W + OM\&R$$

Where ***LCC*** = Total LCC in **present-value dollars**

I = Present-value investment costs

Repl = Present-value capital replacement costs

Res = Present-value residual value (resale, scrap,or salvage value) less disposal costs

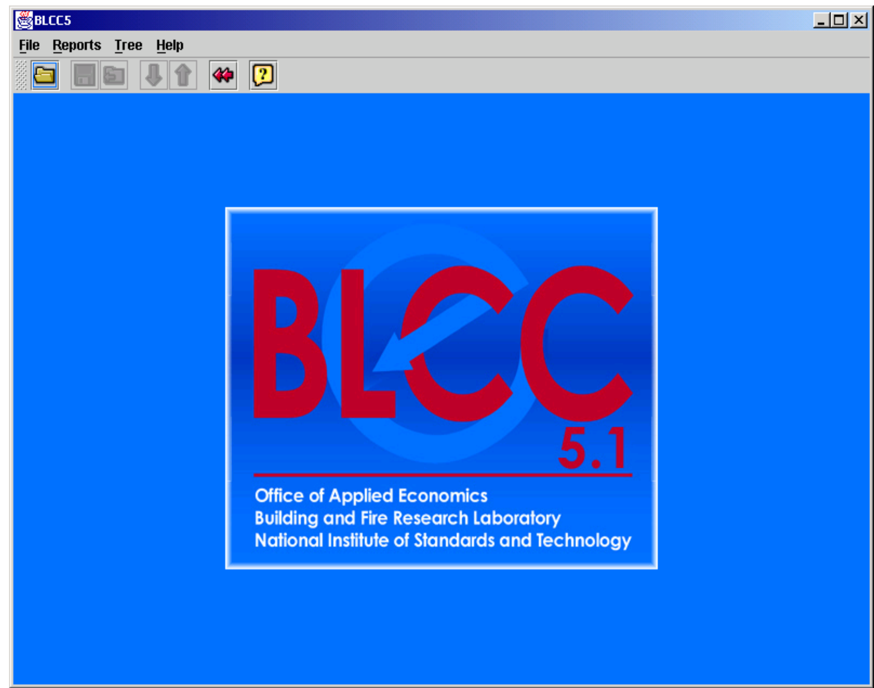
E = Present-value energy costs

W = Present-value water costs

OM&R = Present-value non-fuel operating, maintenance, and repair costs

Step 5: Compute Total LCC for Each Alternative

- **BLCC** computer program automates this process
  - BLCC → **B**uilding **L**ife **C**ycle **C**ost
  - Developed by NIST
  - Windows-based
  - Quick and easy to use
  - Training is available



Step 6: Select the Alternative with the Lowest LCC

- Lowest LCC → most cost-effective
- Don't Forget!
  - Compare each alternative to the Base Case
  - Rank alternatives by LCC

Option	*LCC*
Base Case	$2,450,000
DER 1	1,300,040
DER 2	4,000,200
DER 3	575,000

Prioritized

Option	*LCC*
Base Case	$2,450,000
DER 3	575,000
DER 1	1,300,040
DER 2	4,000,200

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Step 7: Compute Supplementary Measures

- Supplementary measures include:
  - **NS**: Net Savings (NS = $LCC_{alt} - LCC_{base\ case}$)
  - **SIR**: Savings-to-Investment Ratio

    Project savings, discounted over the study period, divided by the investment costs
  - **SPB**: Simple Payback Period

    First-year savings divided by investment costs
  - **DPB**: Discounted Payback Period
  - **AIRR**: Average Internal Rate of Return

    Measures the performance of an investment as a percentage yield

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In Summary

A DER Project is Cost-Effective If…

- Life-cycle costs are lower than alternative (10CFR436.18.c1)
- Net Savings > 0 (10CFR436.18.c2)
- Savings-to-Investment Ratio > 1 (10CFR436.18.c3)
- Adjusted Internal Rate of Return (AIRR) > discount rate (10CFR436.18.c4)
- Payback period << life of equipment or building (10CFR436.18.d)
- Payback period < 10 years (EPAct 1992)

Using the 1391 and 1391C Forms

- What is a 1391 and 1391C?
  - Formatted executive summary of the proposed construction project
- The 1391 and 1391C are used by the military to rank proposals for funding purposes
  - Contains most of the information used by the BLCC programs
  - Fill in the remaining blanks using the Comparative Analysis report outputs from your BLCC analysis

Additional Resources

- "Life-Cycle Costing Manual for the Federal Energy Management Program", NIST Handbook No. 135
  - Required assumptions and procedures
  - Instruction for calculating required indicators
- "Energy Prices and Discount Factors for Life-Cycle Cost Analysis" NISTIR 85-3273, updated annually
  - Required discount rates
  - Fuel escalation rates by census region, fuel type, and usage sector

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Additional Resources

- "Building Life-Cycle Cost" (BLCC) Computer Program (*latest version is 5.1-02*):
  - Computes LCC
  - Calculates savings-to-investment ratio, adjusted internal rate of return, simple and discounted payback periods, etc.
  - Evaluates multiple options
  - Financed projects can be evaluated

http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html#blcc

- FEMP, DOE Regional Offices, and National Laboratories can provide support